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PROCESSING OF SATELLITE IMAGE USING DIGITAL IMAGE PROCESSING

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ABSTRACT:

Pictures are the most effective means of conveying information. A picture is worth a thousand words. Pictures concisely convey information about positions, sizes and inter-relationships between objects. Human beings are good at deriving information from such images, because of our innate visual and mental abilities. About 75% of the information received by human is in pictorial form.

The paper describes the basic technological aspects of digital image processing with special reference to satellite image processing. Basically all satellite images processing information can be grouped into three categories.

- Image rectification and restoration
- Image enhancement
- Information extraction

The former deals with initial processing of raw image data to correct for geometric distortion, the enhancement procedures are applied to image data in order to effectively display the data for subsequent visual interpretation. The intent of classification process is to categorize all pixels in a digital image into one of several land cover classes or themes. This classified data may be used to produce thematic maps of the land cover present in an image.

Our paper comprises of the above stated actions on the data from satellite image (IRS –P6) by LISS-III sensor of 23.5mresolution of 55o7 region on topo sheet. Thus, working on the satellite image we extracted information which has brought us to valuable conclusions, which reveals how image processing can be maneuvered

I INTRODUCTION

Our discussion will be focussing on analysis of remotely sensed images. These Images are represented in digital form. When represented as numbers, brightness can be added, subtracted, multiplied, divided and, in general, subjected to statistical manipulations that are not possible if an image is presented only as a photograph. Previously, digital remote sensing data could be analyzed only at specialized remote sensing laboratories. Specialized equipment and trained Personnel necessary to conduct routine machine analysis of data were not widely available, in part because of limited availability of digital remote sensing data and a lack of appreciation of their qualities.

II DIGITAL IMAGE:

A digital remotely sensed image is typically composed of picture elements (pixels) located at the intersection of each row i and column j in each K bands of imagery. Associated with each pixel is a number known as Digital Number (DN) or Brightness Value (BV) that depicts the average radiance of a relatively small area within a scene (Fig. 1). A smaller number indicates low average radiance from the area and the high number is an indicator of high radiant properties of the area. The size of this area effects the reproduction of details within the scene. As pixel size is reduced more scene detail is presented in digital representation.

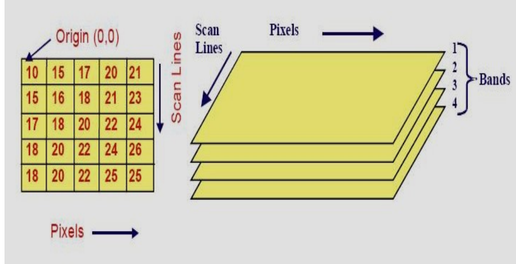

Figure 1 : Structure of a Digital Image and Multispectral Image

III COLOR COMPOSITES

While displaying the different bands of a multi spectral data set, images obtained in different bands is displayed in image planes (other than their own) the color composite is regarded as False Color Composite (FCC). High spectral resolution is important when producing color components. For a true color composite an image data used in red, green and blue spectral region must be assigned bits of red, green and blue image processor frame buffer memory. A color infrared composite 'standard false color composite' is displayed by placing the infrared, red, green in the red, green and blue frame buffer memory (Fig. 2). In this healthy vegetation shows up in shades of red because vegetation absorbs most of green and red energy but reflects approximately half of incident Infrared energy. Urban areas reflect equal portions of NIR, R & G, and therefore they appear as steel grey

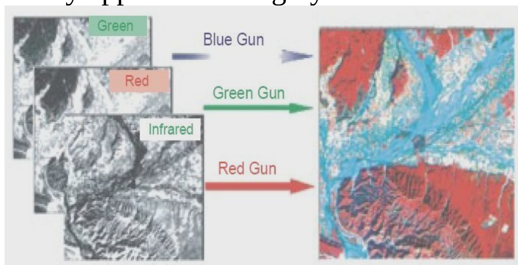

Figure 2: False Color Composite (FCC) of IRS : LISS II Poanta area

IV IMAGE RECTIFICATION & RESTORATION:

Geometric distortions manifest themselves as errors in the position of a pixel relative to other pixels in the scene and with respect to their absolute position within some defined map projection. If left uncorrected, these geometric distortions render any data extracted from the image useless. This is particularly so if the information is to be compared to other data sets, is it from another image or a GIS data set. Distortions occur for many reasons. For instance distortions occur due to changes in platform attitude (roll, pitch and yaw), altitude, earth rotation, earth curvature, panoramic distortion and detector delay. Most of these distortions can be modelled mathematically and are removed before you buy an image. Changes in attitude however can be difficult to account for mathematically and so a procedure called image rectification is performed. Satellite systems are however geometrically quite stable and geometric rectification is a simple procedure based on a mapping transformation relating real ground coordinates, say in easting and northing, to image line and pixel coordinates.

Rectification is a process of geometrically correcting an image so that it can be represented on a planar surface, conform to other images or conform to a map (Fig. 3). That is, it is the process by which geometry of an image is made plan metric. It is necessary when accurate area, distance and direction measurements are required to be made from the imagery. It is achieved by transforming the data from one grid system into another grid system using a geometric transformation.

Ground Control Points (GCP) are the specific pixels in the input image for which the output map coordinates are known. By using more points than necessary to solve the transformation equations a least squares solution may be found that minimises the sum of the squares of the errors. Care should be exercised when selecting ground control points as their number, quality and distribution affect the result of the rectification.

Once the mapping transformation has been determined a procedure called re sampling is employed. Re sampling matches the coordinates of image pixels to their real World coordinates and writes a new image on a pixel by pixel basis. Since the grid of pixels in the source image rarely matches the grid for the reference image, the pixels are re sampled so that new data file values for the output file can be calculated.

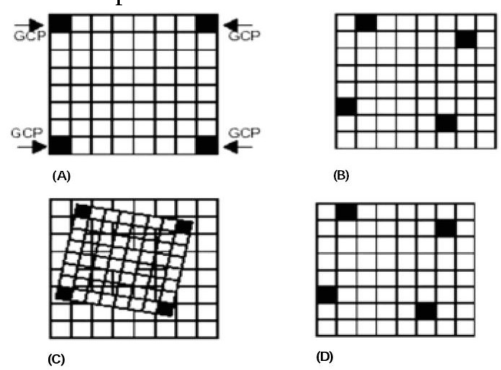

Figure 3 : Image Rectification (a & b) Input and reference image with GCP locations, (c) using polynomial equations the grids are fitted together, (d) using resampling method the output grid pixel values are assigned (source modified from ERDAS Field guide)

V IMAGE ENHANCEMENT

Image enhancement techniques improve the quality of an image as perceived by a human. These techniques are most useful because many satellite images when examined on a colour display give inadequate information for image interpretation. There exists a wide variety of techniques for improving image quality. The contrast stretch, density slicing, edge enhancement, and spatial filtering are the more commonly used techniques. Image enhancement is attempted after the image is corrected for geometric and radiometric distortions. Image enhancement methods are applied separately to each band of a multi spectral image. Digital techniques have been found to be most satisfactory than the photographic technique for image enhancement, because of the precision and wide variety of digital processes.

Contrast

Contrast generally refers to the difference in luminance or grey level values in an image and is an important characteristic. It can be defined as the ratio of the maximum intensity to the minimum intensity over an image. Contrast ratio has a strong bearing on the resolving power and detects ability of an image. Larger this ratio, more easy it is to interpret the image. Satellite images lack adequate contrast and require contrast improvement.

Contrast Enhancement

Contrast enhancement techniques expand the range of brightness values in an image so that the image can be efficiently displayed in a manner desired by the analyst. The density values in a scene are literally pulled farther apart, that is, expanded over a greater range. The effect is to increase the visual contrast between two areas of different uniform densities. This enables the analyst to discriminate easily between areas initially having a small difference in density.

Linear contrast Stretch
This is the simplest contrast stretch algorithm. The grey values in the original image and the modified image follow a linear relation in this algorithm. A density number in the low range of the original histogram is assigned to extremely black and a value at the high end is assigned to extremely white. The remaining pixel values are distributed linearly between these extremes. The features or details that were obscure on the original image will be clear in the contrast stretched image.

Spatial Filtering
A characteristic of remotely sensed images is a parameter called spatial frequency defined as number of changes in Brightness Value per unit distance for any particular part of an image. If there are very few changes in Brightness Value once a given area in an image, this is referred to as low frequency area. Conversely, if the Brightness Value changes dramatically over short distances, this is an area of high frequency. Spatial filtering is the process of dividing the image into its constituent spatial frequencies and selectively altering certain spatial frequencies to emphasize some image features. This technique increases the analyst's ability to discriminate detail.

VI INFORMATION EXTRACTION

Image Classification
The overall objective of image classification is to automatically categorize all pixels in an image into land cover classes or themes. Normally, multi spectral Data are used to perform the classification and the spectral pattern present within the data for each pixel is used as numerical basis for categorization. That is, different feature types manifest different combination of DN s based on their inherent spectral reflectance and emittence properties. The term *classifier* refers loosely to a computer program that implements vary so greatly. Therefore, it is essential that the analyst understands the alternative Strategies for image classification.

The traditional methods of classification mainly follow two approaches: unsupervised and supervised. The unsupervised approach attempts spectral grouping that may have an unclear meaning from the user's point of view. Having established these, the analyst then tries to associate an information class with each group. The unsupervised approach is often referred to as clustering and results in statistics that are for spectral, statistical clusters. In the supervised approach to classification, the image analyst supervises the pixel categorization process by specifying to the computer algorithm; numerical descriptors of the various lands cover types present in the scene. To do this, representative sample sites of known cover types, called training areas or training sites, are used to compile a numerical interpretation key that describes
The spectral attributes for each feature type of interest. Each pixel in the data set is then compared numerically to each category in the interpretation key and labelled with the name of the category it looks most like. In the supervised approach the users defines information categories and then examine their spectral separatebility whereas in the unsupervised approach he first determines spectrally separable classes and then defines their informational utility.

It has been found that in areas of complex terrain, the unsupervised approach is preferable to the supervised one. In such conditions if the supervised approach is used, the user will have difficulty in selecting training sites because of the variability of spectral response within each class. Consequently, a prior ground data collection can be very time consuming. Also, the supervised approach is subjective in the sense that the analyst tries to classify information categories, which are often composed of several spectral classes whereas spectrally distinguishable classes will be revealed by the unsupervised approach, and hence ground data collection requirements may be reduced. Additionally, the unsupervised approach has the potential advantage of revealing discriminable classes unknown from previous work. However, when definition of representative training areas is possible and statistical information classes show a close correspondence, the results of supervised classification will be superior to unsupervised classification.

Unsupervised Classification

Unsupervised classifiers do *not utilize* training data as the basis for classification. Rather, this family of classifiers involves algorithms that examine the unknown pixels in an image and aggregate them into a number of classes based on the natural groupings or clusters present in the image values. It performs very well in cases where the values within a given cover type are close together in the measurement space, data in different classes are comparatively well separated

The classes that result from unsupervised classification are spectral classes because they are based solely on the natural groupings in the image values, the identity of the spectral classes will not be initially known. The analyst must compare the classified data with some form of reference data (such as larger scale imagery or maps) to determine the identity and informational value of the spectral classes. In the supervised approach we define useful information categories and then examine their spectral separability; in the unsupervised approach we determine spectrally separable classes and then define their informational utility.

There are numerous clustering algorithms that can be used to determine the natural spectral groupings present in data set. One common form of clustering, called the “K-means” this approach is iterative; Therefore, it is often applied only to image sub-areas rather than to full scenes.

Supervised Classification

Supervised classification can be defined normally as the process of samples of known identity to classify pixels of unknown identity. Samples of known identity are those pixels located within training areas. Pixels located within these areas term the training samples used to guide the classification algorithm to assigning specific spectral values to appropriate informational class.

The basic steps involved in a typical supervised classification procedure are illustrated on Fig. 6.

a. The training stage
b. Feature selection
c. Selection of appropriate classification algorithm
d. Post classification smoothening
e. Accuracy assessment

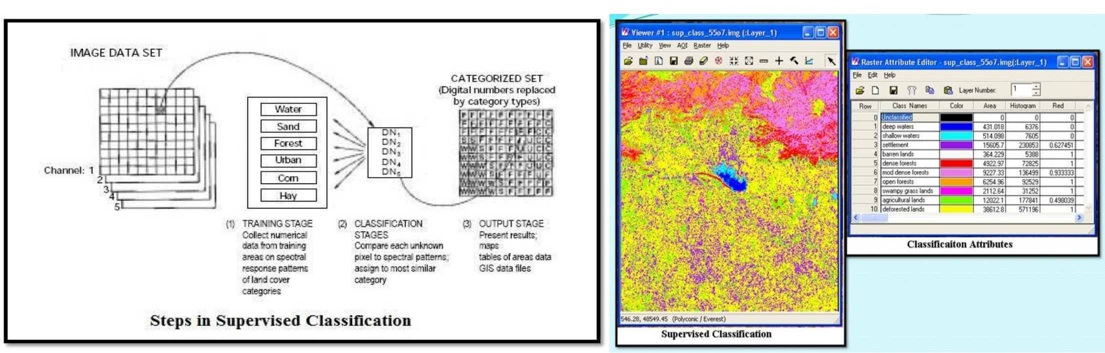

Fig 6

Classification Accuracy Assessment

Quantitatively assessing classification accuracy requires the collection of some in situ data or a priori knowledge about some parts of the terrain which can be compared with the remote sensing derived classification map. Thus to assess classification accuracy it is necessary to compare two classification maps 1) the remote sensing derived map, and 2) assumed true map (in fact it may contain some error). The assumed true map may be derived from in situ investigation or quite often from the interpretation of remotely sensed data obtained at a larger scale or higher resolution.

Classification Error Matrix

One of the most common means of expressing classification accuracy is the preparation of classification error matrix sometimes called confusion or a contingency table. Error matrices compare on a category by category basis, the relationship between known reference data (ground truth) and the corresponding results of an automated classification. Such matrices are square, with the number of rows and columns equal to the number of categories whose classification accuracy is being assessed. Table 1 is an error matrix that an image analyst has prepared to determine how well a Classification has categorized a representative subset of pixels used in the training process of a supervised classification. This matrix stems from classifying the sampled training set pixels and listing the known cover types used for training (columns) versus the Pixels actually classified into each land cover category by the classifier (rows). An error matrix expresses several characteristics about classification performance.

Several other measures for e.g. the overall accuracy of classification can be computed from the error matrix. It is determined by dividing the total number correctly classified pixels (sum of elements along the major diagonal) by the total number of reference pixels. Likewise, the accuracies of individual categories can be calculated by dividing the number of correctly classified pixels in each category by either the total number of pixels in the corresponding rows or column. Producers accuracy which indicates how well the training sets pixels of a given cover type are classified can be determined by dividing the number of correctly classified pixels in each category by number of training sets used for that category (column total). User's accuracy is computed by dividing the number of correctly classified pixels in each category by the total number of pixels that were classified in that category (row total). This figure is a measure of commission error and indicates the probability that a pixel classified into a given category actually represents that category on ground.

Note that the error matrix in the table indicates an overall accuracy of 84%. However producer s accuracy ranges from just 51% (urban) to 100% (water) and users accuracy ranges from 72% (sand) to 99% (water). This error matrix is based on training data. If the results are good it indicates that the training samples are spectrally separable and the classification works well in the training areas. This aids in the training set refinement process, but indicates little about classifier performance else where in the scene.

	W	S	F	U	C	H	Row Total
W	480	0	5	0	0	0	485
S	0	52	0	20	0	0	72
F	0	0	313	40	0	0	353
U	0	16	0	126	0	0	142
C	0	0	0	38	342	79	459
H	0	0	38	24	60	359	481
Column Total	480	68	356	248	402	438	1992

Classification data Training set data (Known cover types) →

Producer's Accuracy	Users Accuracy
W=480/480 = 100%	W= 480/485 = 99%
S = 052/068 = 16%	S = 052/072 = 72%
F = 313/356 = 88%	F = 313/352 = 87%
U =126/2411 = 51%	U = 126/147 = 99%
C =342/402 = 85%	C = 342/459 = 74%
H = 359/438 = 82%	H = 359/481 = 75%

Overall accuracy = (480 + 52 + 313+ 126+ 342 +359)/1992= 84%

W, water; S, sand; F, forest; U, urban; C, corn; H, hay

Analysis of Error Matrix

Table-1

VII CONCLUSION

Digital image processing of satellite data can be primarily grouped into three categories:

- Image Rectification and Restoration,
- Enhancement and
- Information extraction.

Image rectification is the pre-processing of satellite data for geometric and radiometric connections. Enhancement is applied to image data in order to effectively display data for subsequent visual interpretation. Information extraction is based on digital classification and is used for generating digital thematic map.

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